FIRST RESULTS OF CROSSINGS BETWEEN THE ND-01 HIGH OLEIC ACID SUNFLOWER SYNTHETIC AND S_4-LINES SELECTED FOR EARLINESS

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SUMMARY

The US-American high oleic acid sunflower material is relatively late maturing. For sunflower production in cooler climates it is necessary to incorporate the high oleic acid characteristic into early breeding lines. Twelve S_4-lines from twelve different source-populations were crossed with the ND-01 synthetic. The F_1-generation has been cultivated in the experimental field in 1987. In total 227 F_1-heads could be harvested and the F_2-seeds were screened for their fatty acid composition. The range in oleic acid content was from 13.4 % to 90.9 %. Definite classes of distribution could not be observed. There was also no correlation between the oleic acid content of S_4-lines (range from 14.1 % to 29.0 %) and the frequency of F_2-seeds in classes with higher oleic acid contents. These results are in contrast to the ones reported of crossings with HA 89 and other US-American lines, but agree to the results of experiments with wild sunflowers in Spain. The F_1-generations were not earlier maturing than the ND-01 synthetic, as the F_1-seeds had been produced in the glasshouse in the winterseason of 1986/87 and had been very small.

INTRODUCTION

Sunflower oil is comprised primarily of palmitic, stearic, oleic, and linoleic acids, with oleic and linoleic accounting for about 90 % of the total fatty acid content in conventional oils. It has been recognized that there was an inverse relationship between oleic and linoleic acid which was highly influenced by environment, especially temperature during the growing season. Heretofore, cool northern climates yielded high linoleic acid-content sunflower seed, whereas high oleic acid values were characteristic of seed grown in warmer southern areas. While a high linoleic acid concentration is desirable in sunflower oils used in soft margarines and salad dressings, a high oleic acid content is preferred for many other applications (deep-fat frying industry, chemical and industrial purposes), since oleic acid is oxidatively more stable than linoleic acid. Recently, in the USSR the cultivar 'Pervenets' was developed. With this cultivar, however, an increase in oleic acid percentage of total fatty acid content from 64 % to 79 % during seed formation and ripening was observed. The high-oleic acid characteristic of the cultivar remained substantially unaffected by environmental conditions and was incorporated soon in US-American sunflower material.
Literature on the genetic control of high oleic acid content has been surveyed and new results have been reported by Miller et al. (1987). Fick (1984) determined that the high oleic acid trait was controlled by a single, partially dominant gene, designated Ol and reported significant maternal influence. Urie (1985) found not maternal effects. Crosses of different plants from the line P21 with the Pervenets selection did not indicate a single, dominant gene. He concluded that some P21 selections carry major factors and/or modifier genes causing variation in oleic acid contents. Miller et al. (1987) crossed high oleic acid lines from Pervenets like Fick (1984) to the line HA 89. The F_1 seed was intermediate in oleic acid content with reciprocal crosses showing maternal effects. Looking at the distributions in oleic classes of the F_2-, BC- and F_3-populations they concluded that the oleic acid content was controlled by a major gene with partially dominant gene action, Ol, and a second gene, designated ml. When the recessive gene, ml, is

present in homozygous condition, and combined with the gene Ol, oleic levels in seed were elevated to 820 g kg^{-1} of oil or higher.
The objectives of our investigations are to incorporate the genes for the high oleic acid characteristic in our lines, which are relatively early maturing but are still in development, and to see, if it is at all possible, to produce high oleic acid contents in sunflower oil at such a northern location as Braunschweig is.

MATERIALS AND METHODS

A few seeds of the synthetic ND-Ol, which was described by Miller & Vick (1984), were obtained from the North Dakota State University in 1985. Some seeds have been grown in the field and 67 in an isolated glasshouse, to propagate the synthetic. The heads from the glasshouse were mixed together and formed the S_1-generation of ND-Ol. These seeds and seeds from twelve lines (Table 1) were sown in the glasshouse in October 1986. ND-Ol was the maternal parent and was emasculated by using gibberellic acid (Miller & Fick, 1978).

Table 1. Origin of crossing parents (S_4-lines)

No.	Pedigree-No.	Designation of the original accession and country of origin (International automobile abbreviation)
1	03-03-05-02-02	Saturn, CDN
2	06-04-03-01-01	Clairsol, F
3	08-05-05-02-01	Luciole, F
4	09-02-05-02-04	Salyum, SU
5	10-08-05-01-02	Cernianka 66, SU*
6	15-06-03-02-01	Klein, RA
7	24-09-06-03-01	Bulg, IL
8	27-05-08-01-01	Unknown, F
9	29-07-05-01-01	Bamantskij, H
10	30-11-05-02-02	Yugovostok, -
11	32-04-06-01-01	Tschernianka 66, SU*
12	39-05-01-02-01	Unknown, SU

*Probably the same origin, but received from two different institutes

Because of unlucky conditions in spring 1987 seeds had to be pregerminated and planted into the field on 18th May. From the S_1 of ND-Ol, the standard line HA 89 and the twelve F_1-populations up to 39 seedlings have been planted. S_4-seeds of the parental lines, harvested in the field in 1986, were cultivated in single rows of 13 plants. Harvest was on 21st September. In the field start of flowering as number of days after 1st July and plant height (cm) of the single rows were measured. Start of flowering is defined as the day when 20 % of the plants of a row express fertile florets. Fatty acid determination was done at a single random seed of each head by gaschromatographic analysis.

RESULTS AND DISCUSSION

The fatty acid composition of ND-Ol at different growing conditions is compared in Table 2. The seeds from the greenhouse expressed the same high oleic acid content as reported by Miller & Vick (1984). In opposite, the seeds from the field, which have been open pollinated, had a slightly higher than intermediate oleic acid content.

Table 2. Comparison of fatty acid composition of ND-01

Growing conditions	Fatty acid content (%) 18:1	18:2
Field, Braunschweig 1986	51.7	38.6
Greenhouse, Braunschweig 1986	87.3	3.7
Miller & Vick (1984)	88.9	4.4

The S_4-lines started to flower much earlier than the S_1 of ND-01, the F_1-generation or the standard line HA 89 (Table 3).

Table 3. Comparison of start of flowering and plant height

Designation	Start of flowering		Plant height	
	S_4-line	F_1	S_4-line	F_1
1	20	38	70	138
2	19	35	85	146
3	22	37	85	152
4	22	35	110	164
5	17	39	60	153
6	22	42	105	158
7	23	41	125	161
8	17	36	105	168
9	23	43	110	165
10	20	37	110	158
11	18	33	85	145
12	20	40	105	162
Mean	20,3	38	96,3	156
HA 89	34		102	
ND-01	38		143	

After these results start of flowering was not intermediately inherited. But it must be considered that the seeds used for sowing have been gained under very different conditions. The seeds of the S_1 of ND-01, HA 89, both produced in the glasshouse in the summer, and the ones of the S_4-lines from the field were comparable in size. In opposite, the F_1-seeds were very small as they have been produced under poor light conditions in the winter season of 1986/87. Because of the very small seed size the F_1-plants had surely a growth retard of some days compared with the plants germinating from seeds of normal size. Nevertheless, the crosses 2, 4, 8 and 11 are significantly earlier in flowering than ND-01.

The values of plant height (Table 2) demonstrate clearly the hybrid vigour of the F_1-generation over the S_1 of ND-01.

The grouping of oleic acid concentrations of F_2-seeds is complicated by the continuous distribution of the values from 13.4 % to 90.9 % (Figure 1). In contrast to Miller et al. (1987) there were not any clear limits for high, intermediate or low values. The oleic acid concentrations have been grouped into five classes at first (Table 4).

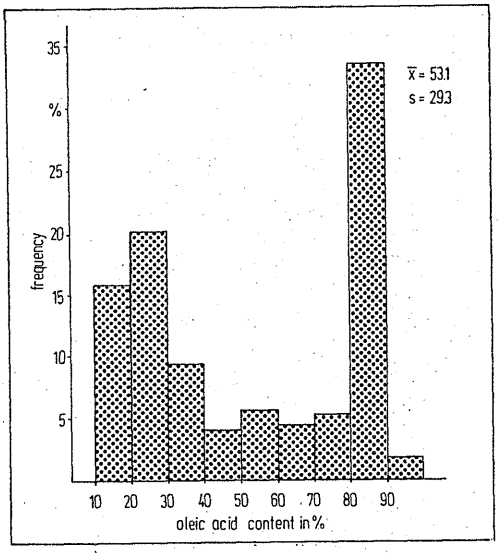

Figure 1. Frequency distribution of oleic acid content of F_2-seeds, 1987

Table 4: Grouping of oleic acid contents of F_2-seeds into five classes

Cross	n	Number of heads with oleic acid contents (%)					Proportion (%) of heads with ≥ 80 % oleic acid
		<20	<40	<60	<80	≥ 80	
ND-01	21	0	3	2	2	14	66.7
1	19	4	4	1	2	8	42.1
2	30	11	8	2	6	3	10.0
3	24	0	8	2	1	13	54.2
4	29	1	4	1	5	18	62.1
5	21	0	5	4	4	8	38.1
6	12	2	7	1	1	1	8.3
7	19	5	3	1	0	10	52.6
8	21	10	6	3	0	2	9.5
9	7	2	2	1	0	2	28.6
10	14	0	9	3	1	1	7.1
11	10	0	3	3	1	3	30.0
12	21	1	8	0	1	11	52.4
Sum	227	36	67	22	22	80	
Proportion %		15.9	29.5	9.7	9.7	35.2	

From this classification no clear segregation ratio could be derived. The results only show that in some crosses (1, 3, 4, 5, 7, 12) there is a higher proportion of heads with more than 80 % oleic acid content than in others. Table 5 contains the oleic acid contents of the S_4-lines. There does not exist any correlation between the oleic acid content of the S_4-lines and the proportion of heads with more than 80 % oleic acid content ($r = 0.01$).

Table 5. Oleic acid content of S_4-lines, 1986

S_4-line	oleic acid content
1	19.3
2	14.1
3	21.7
4	18.5
5	23.9
6	17.9
7	23.2
8	22.9
9	19.1
10	29.2
11	21.4
12	22.1
Mean	21.1

The range of parental values extended from 14.1 % to 29.2 %, so that the low class could be filled with values up to 35 % oleic acid content, as the border between the intermediate and high class 75 % was elected. The number of heads in the classes low, intermediate, and high were then 98, 44 and 85, again no clear segregation ratios.
Our results are in contrast to the ones which have been achieved with US-American lines. One reason can be that as maternal parent a synthetic was used, the S_2-seeds of which had low or intermediate oleic acid contents at a low frequency. So it must be concluded that the S_1-seeds have not been homozygous in the Ol-locus. This would explain the relatively low proportion of F_2-seeds in the intermediate class. How far the not fully homozygous male lines or the extreme weather conditions of the year 1987 (very cold and rainy) had an influence on the modifying gene(s), cannot be enlightened. Fernandez-Martinez & Dominguez-Gimenez (1981) found in the F_2-generation of crosses between high oleic acid wild sunflowers and conventional sunflowers oleic acid contents between 25 % and 85 %. They also could not report definite segregation ratios. The question, if not more genes than two control the high oleic acid characteristic as in safflower (Knowles, 1983), must be answered by further experiments in different environments.

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